Space Weather Technical Forecast

Issued on Friday, 16 August 2024 at 13:13 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/2 Likely in UTC day of Saturday 17 August. R1/R2 Expected throughout, Slight Chance R3.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity recorded at GOES16 has been Low over the past 24 hours, with frequent small mid-ranking C-class flares observed. The largest event of the period was a long-period C7.7 flare peaking at 15/1735UTC, appearing to emanate from AR3786 in the southwest, although there was some concurrent southwest limb-based activity.

There are now up to 13 sunspot regions on the visible disc, with two unnumbered regions now becoming visible near the southeastern limb and AR3790, while a third unnumbered unipolar spot developed in the southwestern quadrant. There are now three main regions on the disc in terms of nominal complexity, although two of these are suffering from significant limb foreshortening effects: AR3780, an Fki/BGD near the southwestern limb, and AR3790, a Dsi/BG on the southeastern. Trends were hard to distinguish here, although AR3790 appears to have developed some new penumbral leading spots in the period. The largest and most apparent of the remainder is AR3784 in the northwestern quadrant, which comprises a large Mt Wilson delta spot, with an east-west magnetic neutral line and consequent shear by differential rotation. The umbrae are relatively symmetric at the time of writing, however this may be temporary. The main trend in the past day in AR3784 has been a fading of its leading spots and mobile small umbrae in the ambit of the main spot. Other trends of note were AR3789 and AR3785 showing proliferation of minor spots, while AR3786 faded.

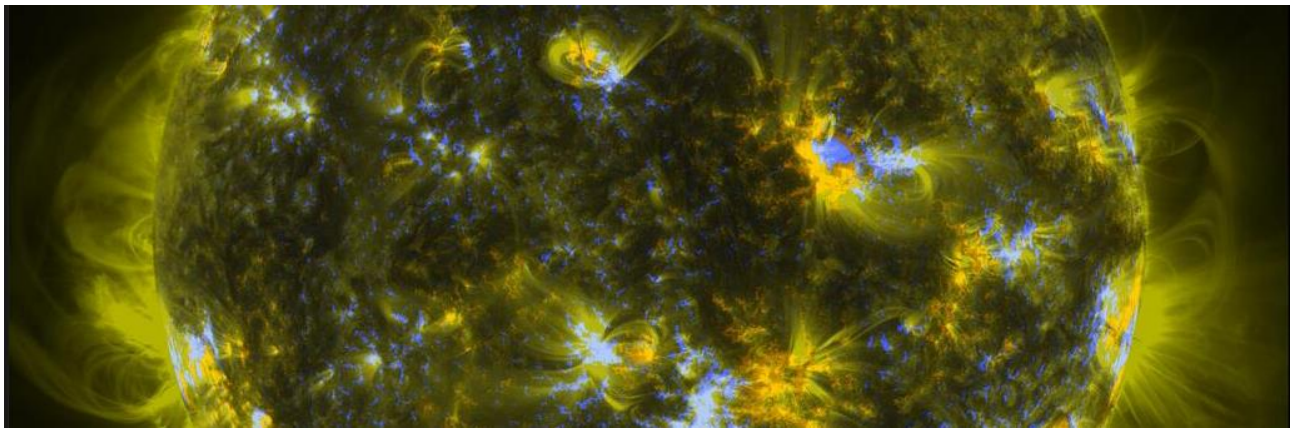

Figure 0: SDO AIA171 and HMIBC composite image of the solar equatorial regions. Note the EUV flux looping over the oncoming eastern solar horizon – part of the rationale for maintaining the current X-ray flare risk beyond the imminent departure of AR3780 in the southwest. Image retrieved 16/1130UTC https://sdo.gsfc.nasa.gov/data/ courtesy aia.lmsal.com.

A possible filament eruption was observed in El Teide H-Alpha imagery at 16/0955UTC from S10W030, with imagery awaited. There was no conclusive Coronal Mass Ejection (CME) evidence

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in the period, although coronal dimming was also seen in the northwest quadrant in the period 16/0001-0200UTC form the magnetic neutral lines in the vicinity of AR3784. At the time of writing this did not appear to translate to any CME on coronagraph imagery, however there is a solar streamer apparently emanating from the northwest disc at present that may pollute any faint signal here. No Earth-directed CMEs were observed leaving the Sun in this period.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE at L1 were reflective of a slow regime. The solar wind speed fluctuated about 350km/s +/-25km/s. The solar wind density was a little more erratic than is typical, with mainly single figure ppcc values but occasionally reaching 10ppcc. The IMF saw a gradual decrease in the 24 hours, falling from early highs of 9nT, while the north-south component moved from a peak +8nT mainly co-aligned orientation (with Earth's field) to become mainly anti-aligned with a nadir of -6 later in the period. The phi angle showed a slow drift within negative (towards the Sun).

The net result of the above solar wind measures was for provisionally mainly Quiet geomagnetic indices, but with a peak of Unsettled Kp '3o' in the 00-03UTC interval (with no obvious mechanism).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 remained at Background levels.

High energy electron flux (greater than 2MeV) observed at GOES16 was at Moderate to Normal Background, with an approximate peak of 200pfu during the UTC evening of Thursday 15 August. The 24-hour fluence was below the Active threshold, with 5.27e6 integrated pfu observed at 16/0001UTC, with a rising then falling trend.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Expected, with a daily Slight Chance of isolated X-class flares. This risk is judged constant throughout, with significant departing regions (AR3780) perhaps in some way compensated for by the weight of numbers of east limb arrivals.

Solar Wind /Geomagnetic Activity: A faint, partial halo CME occurred due to the X1.1 flare at 14/0640UTC, and is forecast to arrive at Earth day 2 (Saturday 17 August). The strength of this is low confidence, with the main geomagnetic activity likely with any subsequent magnetic cloud. This has the potential to be further enhanced by the fast wind of CH58/- on the north-disc, however in itself this is most likely to remain north of the ecliptic. Mainly Quiet geomagnetic activity is therefore expected at first, giving way to Likely G1/G2 Minor to Moderate Storm on day 2 (Saturday 17 August) due to the X1.1 CME arrival. There is a Slight Chance of this event reaching G3 Strong (Kp 7) Storm. Activity should then revert to Quiet over the course of day 3 (Sunday 18 August).

Energetic Particles / Solar Radiation: High energy proton flux is most likely to remain at Background, but with an increasing Chance of breaching S1 Minor solar radiation storm level.

The high energy electron flux is forecast to continue its current subdued diurnal oscillation, with the 24-hour fluence remaining below the Active threshold (1e8 integrated pfu). Confidence in this state of affair's continuation falls in the wake of the CME.

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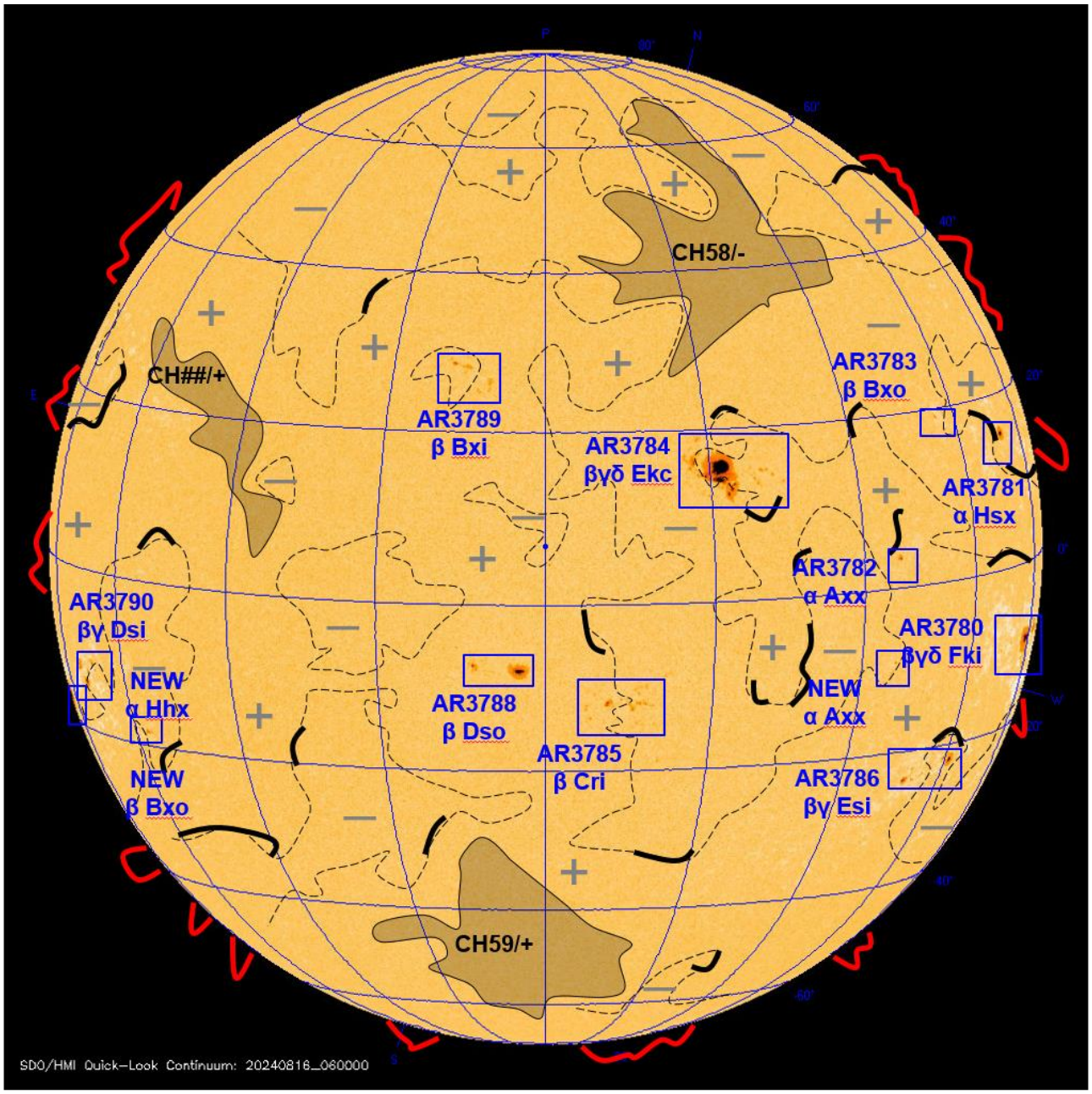
Figure 1. Solar Analysis Valid 16/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No fast winds (directly) feature in the four-day forecast and only one CME.

The above CME was visible as a faint, partial halo CME associated with the X1.1 flare at 14/0640UTC. This has been assessed as having an Earth-directed component, most likely arriving at Earth on day 2 (Saturday 17 August). Given the relatively slow speed of the CME, the initial (shock) impact may be rather limited, with the majority of the geomagnetic activity most likely with the subsequent magnetic cloud, but still likely peaking within the first half of the UTC weekend. This CME is likely to have interacted with the fast wind emanating from negative polarity coronal hole 58 en route to Earth, and while the most likely case is that the fast wind itself should pass north of the ecliptic plane (as on last pass), this is marginal. Earth is very slightly further above the solar equatorial plane on this rotation relative to last (making northern solar hemisphere features potentially more aligned), however the feature is of a less well-connecting polarity at this stage of the cycle, and the fast wind persists in remaining north of Earth on the latest MOSWOC Enlil runs.

Initial Quiet geomagnetic activity should rise to Likely G1/G2 on Saturday 17 August, with a gradual tailing off then expected later in the UTC weekend to leave the new working week Quiet once again. There is a Slight Chance of G3 Strong geomagnetic storm activity owing to complications in the analysis (pollution of the halo from a northwest limb CME) and also any low confidence interaction with a large and presumably intense (from EUV appearances) coronal hole on the northwest disc.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	70	40	1
Strong	G3	No	1	15	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1400	Partial	X1.1	AR3784	610km/s	17/0800UTC -6/+12h	*

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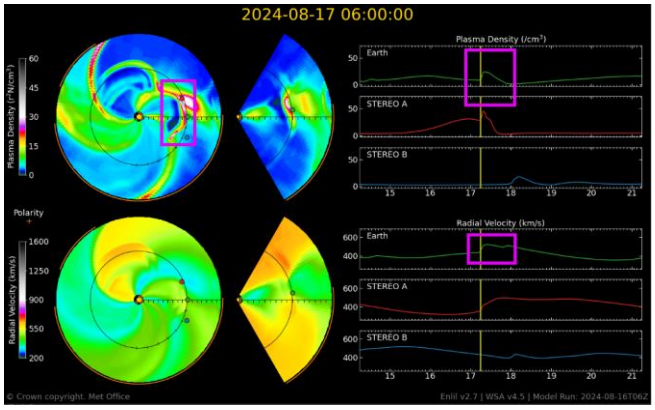
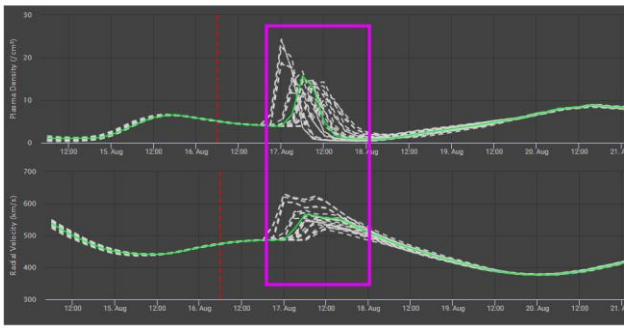
Figure 2: Latest MOSWOC Enlil run (badge time 16/0600UTC) paused at the time of arrival of the X1.1 CME. The intense orange colours of the CH58-associated fast wind can be seen to pass entirely above the ecliptic in this run in the solar wind speed side-slice, although some effect on accelerating the CME itself cannot be ruled out. This lowers confidence in the forecast overall but also gives a potential nod towards Strong G3 geomagnetic conditions should this in fact be slightly further south.





Radio Blackouts - X-Ray Flares:

The recent GOES16 X-ray trace belies the current congestion and nominal complexity on the solar disc, with up to 13 sunspot regions and at least three of these presenting as significantly complex groups. AR3780 in the southwest is currently straddling the southwestern limb, and although there are no obvious changes in this group, its presumed status as an Fki/BGD is maintained. The departure of this group onto the far side into the coming UTC weekend would normally herald a reduction in daily probabilities of significant flares, however a potential successor of sorts - AR3790 - is rotating onto the opposing limb. This group has yet to fully reveal its hand, and may form part of a more complex plage with up to two unnumbered regions now also showing in the vicinity. This group appears to be looping behind the limb in proxies for magnetic field imagery (e.g. SDO AIA171), and there are numerous returning Carringtons of past regions also populating this part of the disc to maintain the daily risks of flares.

The previous paragraph covers potential changes in populations on the disc, however perhaps the most significant region is expected to be present throughout - AR3784 in the northwest. This group essentially comprises one large Mt Wilson delta spot, with a relatively symmetric umbra to its main spot, flanked by a dynamic southern series of smaller spots. The east-west magnetic neutral line is expected to mean that there is a degree of shear inherent in this group, although this has not translated to recent flare activity.

All considered, M-class flares are Expected on all days, with a Slight Chance of X-class, and the recent subdued X-ray trace is felt to be against the expected run of play.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	No	75	75	75	75
Very Active	**R3 to R5 X Class**	No	20	20	20	20

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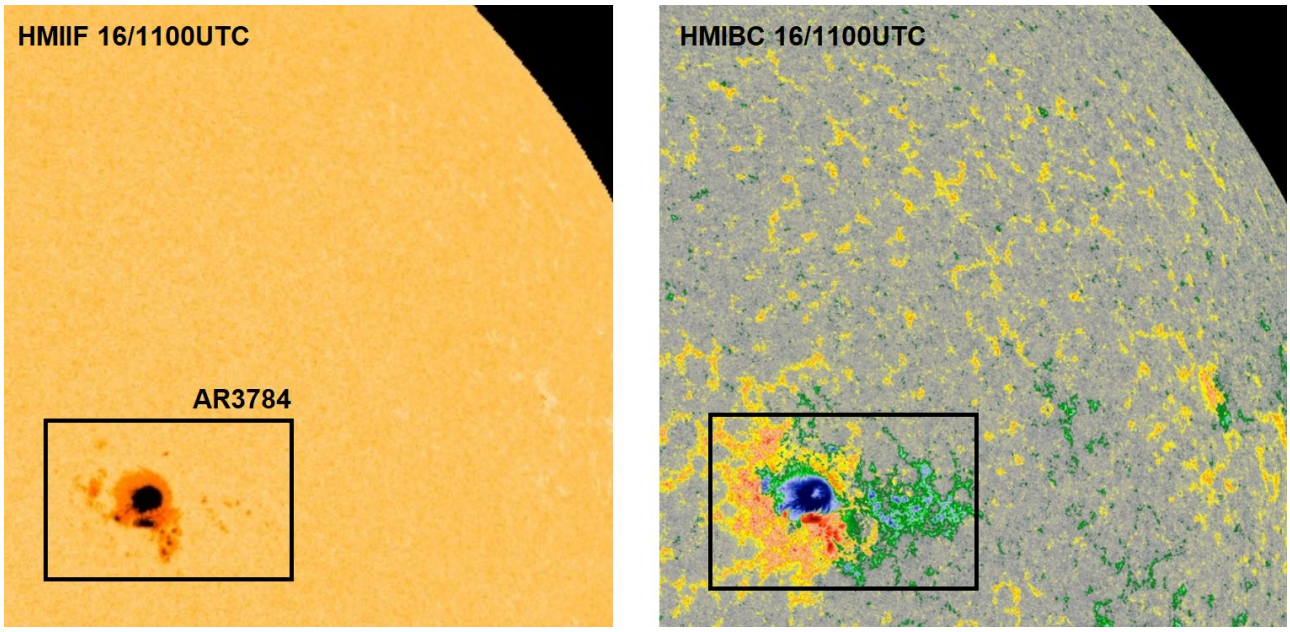
Figure 3: Latest imagery of AR3784 showing its composition as a north-south oreintated region and a dominant Mt Wilson delta in its main penumbral spot.



Solar Radiation Storms - (High Energy Protons):

The daily risk of solar radiation storms should increase in the immediate term as AR3780 and AR3784 both near a peak geoeffective position should either generate any proton-rich events. There is no recent evidence of this despite some relatively large flares, and this is the rationale for slightly decreasing the forecast values relative to historic occurrences for similar Zurich class regions, although the Slight S3+ risk remains.

From the UTC weekend, the gradually decreasing contribution from the by-then far-sided AR3780 should be roughly compensated for by the increasing risk from AR3784, giving a roughly flat trend in the later outlook. The arriving eastern solar limb cluster is thought to lie too far eastward to contribute significantly, and in any case is something of an unknown quantity complexity-wise.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	25	25	25
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux is expected to continue its current muted diurnal trend in the near-term, in the absence of any significant mechanisms to alter this state of affairs and with no coronal hole fast winds due in the four days. Confidence in the continuation of this behaviour in the wake of the X1.1 CME on Saturday 17 August should fall, perhaps giving an eventual Slight Chance of Active 24-hour fluence.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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